

Coupled Chemical Climate Modeling

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Over the past year, climate researchers in T-3 and their collaborators produced a fully coupled climate simulation with extensive interactive chemistry and biogeochemistry. This was the first attempt to include full carbon and sulfur cycles within a coupled climate simulation. In previous climate simulations, only physical quantities were predicted and a few important chemical species, like carbon dioxide and sulfate aerosols, were specified based on observed concentrations or estimated future concentrations. Such models allowed the climate community to predict the impacts of these concentrations on the climate but were not adequate for determining how changes to the climate system might impact the ability of the land and oceans to take up or release additional carbon or sulfur. The current simulation is a first step toward a climate system model in which only the emissions themselves are specified so that the physics and associated feedbacks in the climate system will determine the actual atmospheric concentrations of greenhouse gases and aerosols and their impacts on such important fields as temperature and precipitation.

The model being used is a version of the Community Climate System Model (CCSM) containing atmosphere, ocean, sea ice and land surface components. In addition to the physical fluxes of momentum, heat and water, carbon dioxide and dimethyl sulfide were allowed to be exchanged between these four components. These two specific chemical compounds were chosen for initial study for their important, but distinct, effects on climate. Carbon

dioxide is a leading greenhouse gas responsible for recent climate change. Dimethyl sulfide is an important natural source of atmospheric aerosols, which act as additional condensation nuclei for the formation of clouds. In order to compute these fluxes across the interfaces between models, a full atmospheric chemistry model with 90–100 species and over 200 reactions were required. Since dimethyl sulfide is produced by microscopic organisms in the ocean, a full marine ecosystem and trace gas model consisting of 26 plant, animal, and chemical species were implemented within the ocean model. The land surface also included a large number of carbon pools from various plant and soil properties.

Los Alamos National Laboratory (LANL) researchers, as part of the Climate, Ocean and Sea Ice Modeling (COSIM) project, provided the Parallel Ocean Program (POP) and CICE models as the ocean and sea ice components for the coupled model. In addition, COSIM researchers implemented an ocean ecosystem model of Moore et al. [1] within the ocean model and added an additional trace gas module that includes the production of dimethyl sulfide, as well as a number of other trace gases (such as carbon monoxide and nitrous oxide) that will soon be added to these simulations.

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[1] J.K. Moore, et al., "Upper Ocean Ecosystem Dynamics and Iron Cycling in a Global Model," *Global Biogeochem. Cycles* **18**, doi 10.1029/2004 GB002220 (2004).

Dimethyl Sulfide Flux (nanomoles/m²/sec) from Ocean to Atmosphere
December Average of Coupled Year 5

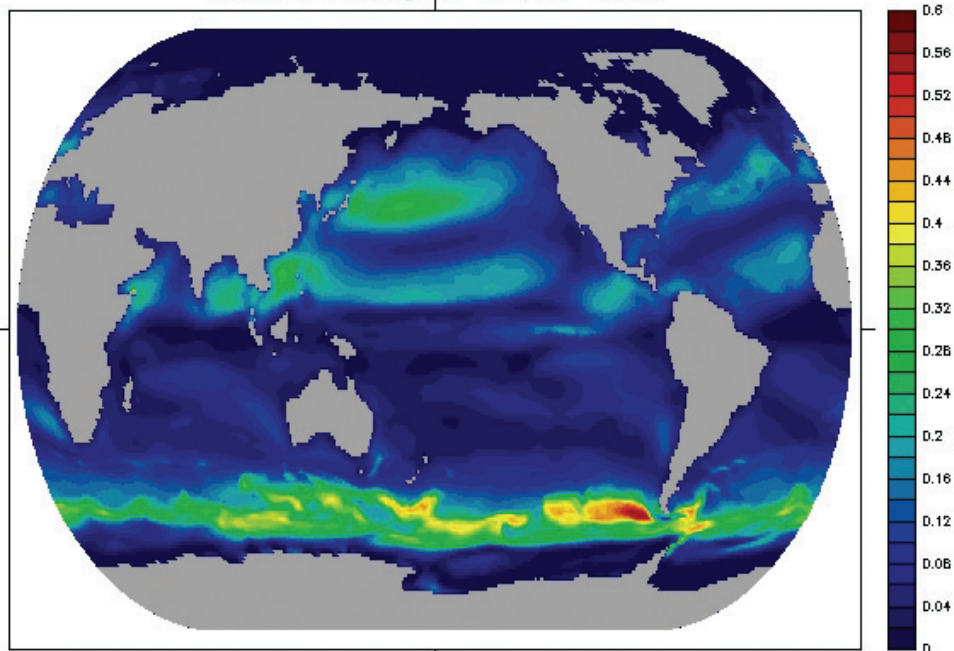


Fig. 1.
Average of dimethyl sulfide flux (nanomoles/m²/s) from the ocean to the atmosphere in December of year 5 in the fully coupled simulation.